ON THE PREVENTION

OF

FIRES IN THEATRES.

By C. JOHN HEXAMER.

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ON THE PREVENTION OF FIRES IN THEATRES.

By C. JOHN HEXAMER.

[A paper read at the Stated Meeting of the Franklin Institute, held June 21, 1882.]

Since the beginning of this century estates worth over one hundred million dollars, and thousands of lives, have been destroyed by theatre fires, while thousands of others were fortunately saved from the same fate.

First, as to the number of theatres in general: Europe contains 1486 theatres, of which France has 337; Italy, 296; Spain, 168; Great Britain, 164; and Austria, 152. The United States have 557 (about). Paris has 40; London, 32; New York, 21; Naples and Milan, 31 each; Philadelphia, 12; and Rome, Turin, and Brussels, each 10.*

Comparing the number of theatres with the populations, we find the following ratios:

Italy,	one theatre for every	75,000	inhabitants.
United States,	" " "	90,000	"
Spain,	" " "	93,000	"
France,	" " "	110,000	"
Great Britain,	" " "	184,000	"
Austria,	" " "	235,000	"
Russia,	" " "	1,360,000	"
Turkey,	" " "	2,000,000	"

Theatre fires can have but two eventualities: either the fire is extinguished in the first minute, or the entire theatre destroyed. This is easily accounted for by the extraordinary danger, from fire, of our modern theatres.

In the large space called the stage (of which the audience sees comparatively little) we find immense masses of laths, boards, and other wood-work, which, by long heating, are entirely dry, and may, therefore, be instantly inflamed. Among these we find great quantities of gauze, coarse canvas, and other easily inflammable goods. Furthermore, ropes, paper soaked in varnish, paste-board, etc., in short, a mass as readily inflammable as could well be found.

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* The above statistics were taken several years ago. An article in the *Daily News*, a short time ago, shows that London, at present, has 57 theatres, 408 music halls and 475 other places of amusement, which can, on the average, accommodate daily 302,000 persons. The average daily attendance at the theatres is about 126,000.

In the midst of these is the more or less well-arranged heating apparatus; also a great number of gas flames, each forming a dangerous sphere around itself.

The danger is still increased by these combustible materials not remaining stationary. They are let down, drawn up, shifted about, and are, therefore, more liable to come in contact with the gas flames. At times it is necessary to provide illuminating effects temporarily, as, for instance, where the chandelier of a ball-room scene, which is fed by a rubber hose, must be removed during change of scene.

We are particularly careful in places filled with combustible materials, to enter them with closed lanterns only, eschewing open lights and candles. On the stage, to the contrary, guns are fired off, torches swung, fireworks set off, while, at the same time, scenes of laths and canvas are let down, as, for example, in the last scene of "Sardanapalus." A German writer on this subject says: "One who has been behind the scenes during the performance of a spectacular piece, and found himself suddenly enveloped in a sea of fire, and has noticed how a force of men are engaged in extinguishing (by means of wet rags suspended on long poles) the sparks which have settled on the scenery; who has noticed how, notwithstanding all care, fiery objects fly from their prescribed course, or has seen how a piece of firework too strongly loaded throws everything into confusion; one who sees this for the first time cannot overcome the feelings of astonishment and fear; and this, when viewed from the audience, is no more than is common in spectacular pieces."

These circumstances, not taking into account criminal negligence, show how readily a stage may be set on fire; and how, if not extinguished immediately, or at most in the first minute, it must spread with immense rapidity and destroy the whole building. After this time the most strenuous efforts are futile. During such intense heat the, so called, fire-proof constructions become useless, the strongest walls are destroyed, marble is burnt into lime, cast iron disintegrates, wrought iron loses all tenacity, and the entire building is destroyed.

Of the number of theatre fires we have but a poor register. The writer has collected a list of some 150 theatres which have burnt down within the past 100 years. This table does not—although great care was spent upon it—include, by any means, all of these disasters. With the news of a newly burnt theatre we generally get the notice that it had been built in place of one also destroyed by fire. So, for example, in London, the "Haymarket Theatre" was burnt in 1789 and 1867; the "Covent Garden Theatre" in 1808 and 1856; and "Astley's Amphitheatre" in 1794, 1830, and again in 1841. In London there have been, since 1772, not less than 18 total losses of theatres, and in Paris, 20.

It is, therefore, not too much to say, that destruction by fire is the natural end of theatres. In looking over a table of theatre fires we are struck by the rarity of such calamities in Italy.

The explanation of this fact is neither to be sought in the more solid mode of building, nor in any particular care or prudence of the Italians, but partly in the mild climate, making heating unnecessary, and partly in the character of their performances. The Italian, of all grades of society, seeks in the theatre not so much sensational and spectacular pieces, but he wishes foremost to hear music, and thus many dangers disappear. With our growing taste for spectacular pieces, the number of theatre fires must increase.

It has been found that more than half (52 per cent.) of all theatre fires occur from December until March; a fact easily explained by the use of heating apparatus, and by the production (especially in England) of Christmas spectacles.

The time of day at which such fires occur is a consideration of great importance. It has been calculated that 13 per cent. of all theatre fires occur in day time, before, or during rehearsals, which are generally held by gaslight; 2 per cent. in the evening before the audience has entered; 21 per cent. during performances; 48 per cent. during the two hours following performances; and 16 per cent. later at night. The statement may excite surprise that nearly one-half of all theatre fires occur two hours after the performances, and that it is this period which is the most dangerous. It has been stated above that, in theatres, flames spread with lightning speed, but in case a spark has settled on a piece of canvas, it may glow for a long time unnoticed, until a sudden draft causes it to burst into flames. This cause, combined with the poor, or entirely neglected, watching of stages at night time explains this seemingly peculiar fact.

As before stated, in case of fire, theatres are always total losses, or, as it has been said: "It is a pity for every drop of water which, in such

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a case, is used otherwise than for the protection of the surrounding buildings."

Of all the better known theatre fires, it has been found that 23 per cent. were isolated, and on this account the further spreading of the flames was impossible; 36 per cent. greatly endangered the surrounding buildings, and these were only saved by the most strenuous efforts; and 41 per cent. (nearly half) extended to other buildings. Theatres should, therefore, not expose other buildings.

In 1867 the fire at the "Haymarket Theatre," London, notwithstanding the greatest efforts, destroyed a great number of surrounding houses, making 400 persons homeless. The theatre fire at Cincinnati, 1866, caused the destruction of several of the largest banks, offices, and other buildings. The fire at the "Bowery Theatre," New York, 1867, spread throughout the entire block. In 1866 the fire at the "Academy of Music," New York, destroyed a church, an academy, with valuable collections, and many dwellings and factories. These few cases will suffice to show how necessary it is that theatres should not be connected with other buildings, and that they should be built on large lots.

That existing defects may be oviated and remedies proposed, it is necessary we should know (1) the cause of a theatre fire, and (2) where it originated.

The most frequent cause of fires is carelessness. An instructive example of this is afforded by the destruction by fire of the "Grand Opera House" at Dresden. With incredible carelessness, workmen had been ordered to repair some rubber hose with a benzine solution; the garret in which they worked being dark, they lighted it by candles. These inexperienced people carried on this dangerous business for some time, until at last, on the 21st of September, 1869, one of the workmen, in lighting a candle, lit the benzine on his hands, and at the same time some rags; in a short time the whole building was in flames, and totally destroyed. With such management, it may not excite surprise to learn that during the fire all water reservoirs were empty, and that the wire curtain was rusted fast, and could not be let down.

The question is frequently asked, "What can be done to diminish the combustibility of the materials employed on stages?"

This is not an easy question to answer; that the heating and lighting appliances, divided over manifold points of the stage, as well as manipulations with open lights, and even fireworks, are necessary for modern theatrical performances, there is no doubt. In themselves they are not dangerous; but the danger lies in the great quantity of wood-work, gauze, coarse canvas, and other readily combustible materials of which scenery is made. If we remove the ready combustibility of these objects, not every spark or flickering gas flame will endanger the existence of the entire theatre, and the special danger of the stage and rigging-loft is immediately overcome.

The experiment of making certain pieces of decoration of an incombustible material has been tried many times, and with considerable success. Especially the flies, as being most exposed and hanging among the border-lights, have in some cases been made of fine wire gauze. The interstices were then filled with an incombustible substance, and the flies were then painted in the usual manner. This method certainly gives entire security against fire, and the greater amount of first cost is more than counterbalanced by their greater durability; but the inconvenience of handling such pieces is greatly increased by their greater weight, making them practically impossible for drops, and larger wings and flats.

Another device is to protect the wood and canvas by painting it with suitable materials, and thus to make it incombustible.

After the rebuilding of the "Opera House" at Munich (destroyed by fire, 1823) the wood-work was given a few coats of water-glass. This kept well for twenty years, but later trials showed that the coatting of water-glass had changed its *chemical composition, and gave no further security.*

Water-glass is further objectionable on account of the gloss it imparts to scenery, thereby reflecting light, and spoiling the artistic effect of the painting.

The impregnation of scenery, before painting, has been strongly advocated, and especially of the aforementioned flies. Some of the different substances used for this purpose are alum, sodium sulphate, borax, the soluble fluorides, and calcium sulphate. It was claimed that by impregnation canvas became so far incombustible that it could neither propagate flames, nor glow for any length of time, and even under great heat would only char.

After the fire at the "Berlin Opera House" the authorities ordered the soaking of all scenery in a solution of alum.

The same question was raised, and given to a commission to decide, some twenty-five years ago, in Paris. On account of the report of this commission an ordinance was issued enforcing the impregnation of all scenery. This was carried into effect in several theatres until, unexpectedly, some impregnated gauze was set on fire by the heat of a candle. The mayor had the case investigated. It was found that the ingredients used had lost their protective power, and had changed the chemical composition of the paint.

The writer ascribes the failure of these experiments to the manner in which the process was conducted; the canvas being, in all cases, merely soaked in the solution, and then dried and painted. If a piece of canvas is soaked in water-glass, and allowed to dry, the liquid, in losing its water, will contract more and more, until finally the solid particles will sit loosely on the *yarn* of the canvas.

Again, sodium tetra-silicate (water-glass being soluble in water) is dissolved on coming in contact with water. The water-colors used in scene painting may, therefore, have dissolved the greater part of the silicate at the start.

To obviate this the author would suggest the following: After thoroughly soaking the canvas in water-glass it should be placed in a dilute solution of hydrochloric acid; this would precipitate the silica inside of the *fibers* of the yarn itself. The reaction being the formation of silica, sodium chloride, and water; viz., $Na_2Si_4O_9 + HCl = 4SiO_2 + 2NaCl + H_2O$. The silica, being insoluble in water, could not be washed out, and, on account of its precipitation in the fibres, could not readily be thrown out, this process being a parallel case to the use of a mordant in dyeing; the linen in that case being first soaked in color, and this then precipitated (made fast) by the mordant. As silica has no gloss, this process would also get over that difficulty.

Of course, any other incombustible substance precipitated into the fibres will answer as well as the above.

Other solutions recently recommended for purposes of impregnation are: Versmann's and Oppenheim's, who advise a solution of 2 parts of sodium tungstate with 3 parts of sodium phosphate; Nicoll, one consisting of 6 parts of alum, 2 parts borax, and 1 part dextrine dissolved in soap-water; Siebdrath uses 5 parts of alum, 5 of ammonium phosphate, and 100 parts water; Patera, 15 parts borax, 11¼ parts of sodium sulphate, and 100 of water; Martin, 8 parts ammonium sulphate, 2½ of sodium carbonate, 3 parts boracic acid, 2 of borax, 2 of starch, and 100 of water. And very recently it has been suggested to use a solution of magnesium chloride.

That something must be done to protect all easily inflammable parts, there is no doubt. The enormous danger of modern stages, and the dislike of insurance companies to writing these risks, will be a great factor in favor of the introduction of rational measures.

These remarks apply not only to stage-settings, but also to the light and flimsy suits of players, and especially to the dresses of the ballet. The great number of persons killed by the burning of clothing is astonishing. The sad death of the renowned dancer Emma Livery, Paris, 1862, and the burning to death of 12 persons at Philadelphia, February 17, 1861, are sufficient examples to show the necessity of this measure.

All the theatres of London have wet rags constantly on hand that, in case of accident, instant assistance may be rendered.

The combustibility of scenery is also greatly lessened by painting it on both sides, as the fuzz on the back of scenery, along which flames spread, is thereby destroyed.

The author's attention was first called to this fact by Mr. Higbee, chief machinist of the American Academy of Music, Philadelphia.

This gentleman held canvas painted on both sides within an inch of a "Bunsen burner," thus only charring it. The writer has frequently repeated this experiment, but he must here state that this only holds good as long as the canvas is well-covered with paint, and not after the paint has partly dropped off.

Scenery might be made much safer than it is by simply whitewashing the back of it, thus destroying the fuzz. This is an exceedingly cheap and simple operation, and there can be no excuse for not carrying it out.

Of late the use of asbestos for scenery, and especially for the "fire-drop curtain," has been agitated, but, as yet, nothing really practical has been done in this direction.

A fact not generally known is that it is not so much canvas scenery which is dangerous as the gauzes used in especially large quantities in spectacular pieces. This stuff is inflamed on the slightest provocation, and spreads like "wild-fire." It may be safely stated that a theatre which uses much gauze is *by far* more dangerous than one that uses little.

In its construction, a stage should be as nearly like the shaving-vault of a planing-mill as possible. The rear and two sides of the stage (including green-and dressing-rooms) should be enclosed by thick brick walls, brick being the best masonry in case of fire. It stands when granite has disintegrated and marble has been burnt into lime.

The roof and roof-trussing should be made as nearly as possible fire-proof, as the rigging-loft is generally attached to the roof-trussing.

To divide the stage from the auditorium a wire drop-curtain becomes necessary. The failure of wire curtains in the case of the "Dresden Opera House," and again in the recent calamity at Vienna, has shaken public confidence in them. But in both cases negligence was the cause of their failure; the former was allowed to rust fast, and the latter was not let down.

It is necessary, therefore, that a wire curtain should (1), *be kept in perfect order;* and (2), *be automatic.*

It should be let down after every performance, and should not be raised until fifteen minutes before the beginning of performances. This would insure (1), its good order, and (2), would, in case of fire during the night, perhaps save the theatre.

A circumstance which has as yet not received the proper attention is the use of automatic curtains. At present the safety of theatres having wire drop-curtains depends entirely upon the coolness of the men having them in charge, and how little this can be depended upon the late Vienna fire clearly showed.

It is of the greatest importance that proscenium boxes should be of brick or iron, as some of the stage-settings are very near them, and in case of fire these boxes might be ignited in the time required by the curtain to lower itself.

The wall dividing the stage from the auditorium (proscenium wall) should be of brick; starting from the foundation, it should be broken by the *stage opening* and orchestra doors only. Above the *stage opening* an arch should be sprung, and the wall carried up on this at least 18 inches above the roof.

The joists and flooring-boards of the stage should not extend beyond one foot of the proscenium wall, as they would transmit flames to the wood work of the orchestra. In the same manner, the joists of the parquet should extend merely to this wall, and *by no means through it.*

The doors contained in this wall should be lined with iron, as solid iron doors, in great heat, soon become warped and useless, while iron-lined doors, in the greatest heat, retain their shape. This, at first sight, strange fact, is well known to "insurance men."

In case of fire a solid iron door offers no resistance to warping; in a lined door, on the contrary, the sheet iron, which tends to warp, is resisted by the interior wood, and when this burns into charcoal it still resists all warping tendencies. All doors contained in "fire-walls" should have springs or weights attached to them, so as to be at *all* times closed. Fire-doors can be shut automatically by a weight, which is released by the melting of a piece of very fusible solder employed for this purpose. "So sensitive is this solder that a fire-door has been made to shut by holding a lamp some distance beneath the soldered link and holding an open handkerchief between the lamp and link. Though the handkerchief was not charred, hot air enough had reached the metal to fuse the solder and allow the apparatus to start into operation."

These solders are alloys more fusible than the most fusible of their component metals. A few of them are: Wood's alloy, consisting of:

Cadmium,	1 to 2 parts.
Tin,	2 parts.
Lead,	4 parts.
Bismuth,	7 to 8 parts.

This alloy is fusible between 150° and 159° Fahr. The fusible metal of d'Arcet is composed of

Bismuth,	8 parts.
Lead,	5 parts.
Tin,	3 parts.

It melts at 173·3°. We can, therefore, by proper mixture, form a solder which will melt at any desirable temperature.

As before stated, one of the chief dangers of theatres consists in the numerous gas-flames, and not only of the stage proper, but also those of dressing-rooms. It seems impossible to supply actresses with enough light in dressing-rooms. A well-known prima donna, not being satisfied with large brackets on each side of her bureau, had twelve candles placed around her glass, as the informant remarked, "for her to see her ugly face." It is of the greatest importance that gas brackets should be supplied with wire baskets, and that swinging brackets should be allowed under no circumstances; and still proprietors of theatres have constant annoyance by actors tearing off these wire covers.

That not only the gas brackets of dressing-rooms, but *all* brackets, should be protected by wire baskets, and that all swinging brackets should be eschewed, goes without saying.

Particular attention should be paid that foot and border lights are covered with wire screens. These lights should be lighted by electricity, as many fires are caused by retaining the old method of lighting, by alcohol lamps suspended on long poles. A careless or intoxicated man tries to light the border lights, strikes, with his lamp, a piece of gauze, and in a short time the whole building is in flames. Considering the proximity of these lights to flies, it is wonderful that this is not a more frequent occurrence than it is. Care should be taken to keep flies, and especially those of gauze, at a proper distance from border lights. Many fires have been caused by allowing scenery to hang over these lights.

We must now briefly turn our attention to fire appliances in theatres. Every great disaster causes a temporary fit of virtue among theatre managers, during which new fire appliances are introduced; but very soon this dies away, and appliances are allowed to become out of order and worthless.

The simplest and one of the best of fire appliances is the "fire-bucket." A bucket of water at hand to be thrown on a flaming piece of gauze is worth all the fire appliances in the city fifteen minutes later. Therefore, fire-buckets should be kept *constantly filled* all over the premises, for an empty bucket is worse than none, as it only takes up space. These should be kept not only on the floor of the stage, but also in its most dangerous part, the rigging-loft.

Plugs with hose attachment should be placed in every part of the building—the galleries of the auditorium, the stage, the rigging-loft, etc., etc., as there cannot be too many of them. The closets containing them should be marked with large letters, as FIRE PLUG. Frequently firemen, on arriving at burning theatres, have no idea where the plugs were, as they are all boxed up. A skillful designer can readily make these tasteful in appearance.

All plugs should have their hose attached, ready for instant use, as no one would take the nozzle off of a plug and attach the hose in the midst of the smoke and flames of a burning stage.

But plugs should not be solely relied upon for protection in theatres, from the fact that their usefulness depends entirely upon the courage of the employés. It is too much to ask a man to stand and fight fire when he knows that there is a tinder-box between himself and safety, and that at any moment a drifting spark may cut off his only chance of escape. Sometimes such heroes do exist, who pay for their bravery with their lives, but these are only warning examples to others not to risk their own in similar efforts.

In this case we must again take our resort to automatic means, and for this purpose automatic sprinklers, which have been in use in mills for some time, would be of great value.

As a plentiful supply of water is not always at hand, and as steam-pumps frequently get out of order, large reservoirs should be placed on top of theatres. These should be placed on top of the auditorium and not in the rigging-loft The stage, as the most inflammable part, being generally ignited first, would (if the reservoirs were placed on it) deprive the remainder of the building of water.

In order to keep the water in these tanks from freezing, the exhaust-steam pipe of the engine should be made to pass through it; or, as this is not always convenient, it should be mixed with salt (salt water having a lower freezing-point than pure water). The addition of salt would also have the wholesome effect of preventing the formation of algæ (the green slime found on ponds and other still water), which are obnoxious by their smell and by the tendency they have of closing the pipes.

Every theatre should have a fire brigade consisting of at least five men; these should be present at all performances, and should be perfectly familiar with the theatre and all its fire appliances.

At Carlsruhe (the seat of the famous polytechnic school) the authorities, after the great fire of the "Hoftheater," organized a fire patrol of students. These are stationed all over the theatre, know all appliances, and, as a corps of gentlemen, must be much superior to ignorant men, both in case of fire and in quieting a panic.

Watchmen should be constantly on the premises, and, to control them, watch-clocks should be fixed in different parts of the building.

Automatic fire-alarms, placed in various parts of the stage, would be of great use, as the fire department is generally notified too late.

We now arrive at the most important question: *The safety of audiences.*

From the numerous accounts of theatre fires which the author has collected he finds that loss of life is caused by (1), suffocation by smoke; and (2), the crushing and trampling of the panic-stricken masses.

Experience shows that death is mostly caused by suffocation, and that the burning of bodies is a subsequent occurrence, taking place after life has already become extinct. This was again clearly illustrated by the late Vienna fire, as will be seen from the following account of a civil engineer, given at the time, in several Vienna papers:

"This gentleman, with his wife, was sitting in the second gallery, and, fortunately for himself, was one of the first to discover the fire; they quickly got up and walked out, while the majority of the audience had no idea of the occurrence. The lights were burning until they reached the last steps of the second story, when all lights were suddenly extinguished. While they were still in doubt in what direction to go, they were carried, by a sudden rush, to the right, and found themselves in front of a glass door. This door was broken open, when they saw that they were, with some twenty-five other persons, on the balcony fronting on the '*Hessgasse*' (Hess Street)

"The gentleman, seeing his wife safe, returned to the corridor and loudly shouted: 'This way for safety!' He received no answer. He then went further, until checked by the smoke, but already, at this short distance, saw several corpses. Thereupon he went back to the balcony and saved himself by jumping on the cloths in the street."

He concludes from this that after this short time, already, every one in that gallery was suffocated. Although we cannot tell how long it took to suffocate all these people, we can safely state that they were suffocated and not burned to death, the bodies having been burnt later.

We must, therefore, get rid of the smoke in the quickest and best manner possible. This question has been solved by the ingenious device of Hofman, which acts in conjunction with his automatic drop curtain, and by Mr. Louis Sues of Chicago.

The intense smoke in the auditorium, during a fire on the stage, is caused by a draft of hot air from all parts of the house towards the open doors and ventilator.

The latter is usually situated above the main chandelier in the centre of the auditorium ceiling. This draft may frequently be noticed by the sail-like outward bulging of curtains.

We must, therefore, form a counter draft which, in case of fire, would be strong enough to overcome the combined action of the doors and ventilator.

This could best be accomplished by a chimney or flue on the top of the stage which would take off all smoke and cinders. Or, as before stated, *making a perfect shaving vault of the stage.*

We will now describe the different solutions advanced for this problem, beginning with the simplest.

A good idea was suggested a short time ago by one of the inspecting chiefs of the New York fire department. It was, to make the roof over the stage a vast skylight, the glass of which could be broken in case of fire and a draft thus created which would carry the flames upwards and prevent them spreading to the auditorium.

Next in order comes Mr. Sues' smoke flue, the description of which I quote from his patent specification. Fig. 1 is a vertical section. Fig. 2 is a detail in perspective.

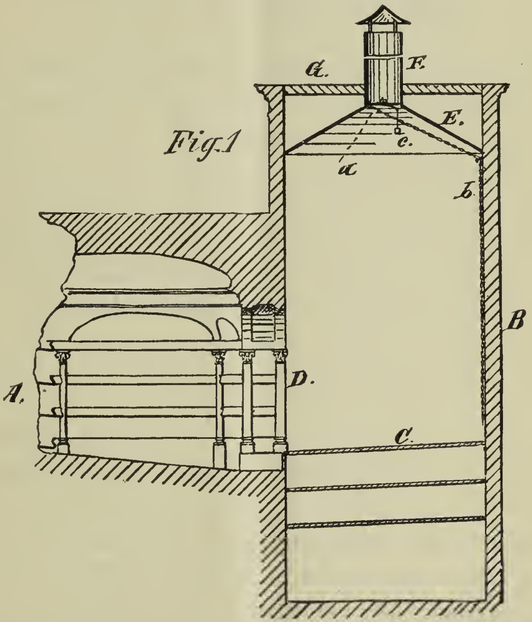
Fig.1

"Theatres frequently take fire and in almost all cases the fire originates in that portion of the building devoted to the stage and scenery. There is usually a draft from the stage to the auditorium, especially when the doors are opened and the flames and smoke pass rapidly from the stage to the audience-room.

"The object of my inventions is to construct theatres so that this difficulty will be obviated to a great extent, and it consists in a large outlet in the roof over the stage for the passage of smoke in case of fire, so that a current of air will be induced from the auditorium to the stage instead of from the stage to the auditorium, and combining with such outlet a ceiling over the stage portion of the building which will for a considerable time resist the action of fire, thus giving the audience time to escape.

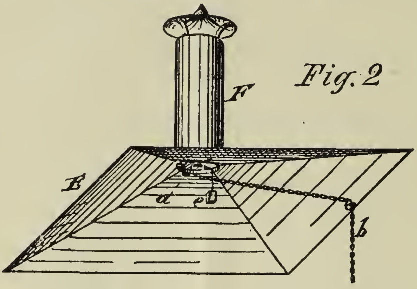
Fig. 2

"In the drawings, *A* indicates the auditorium; *B* that portion of the building devoted to the stage; *C*, the stage; *D*, opening between the stage and the auditorium; *E* is the ceiling over the stage. This ceiling I make practically fire-proof, either by making it wholly of metal or by the use of metal joists with wire or wire-cloth for lathing, and usual plastering, or in other suitable manner. *F* is a large passage to be made of fire-proof material. It passes through the roof *G*. Its lower end is properly secured in the ceiling and is open, except when closed by the valve *a*. *b* is a chain by means of which the valve *a* can be opened. *c* is a weight which holds the valve in position when closed.

"The operation is as follows: If a fire breaks out upon the stage the valve *a* is to be immediately opened. The ascending heat and smoke will rise to the ceiling and escape through *F*, thereby producing a current from the auditorium to the stage, instead of the reverse, thus keeping the smoke and flames from the audience-room while the audience is escaping. In cases where a fire-proof drop-curtain is used suitable openings may be somewhere provided to admit air to the stage.

"In theatres of the usual size the passage *F* should be about six feet in diameter. It may be carried some distance above the roof which will increase the draft.

"Two or more of these passages *F* may be used. The opening at the top of the passage *F* may be protected from storms by caps."

This is an excellent device, the only objection to it is that it is not automatic; its usefulness, in case of fire being, therefore, dependent on the coolness of the men having it in charge.

The ingenious device of Hofman combines an automatic wire drop-curtain, and automatic smoke flue and an automatic fire alarm. This device will act without the aid of a single hand, being entirely automatic.

It consists of a safety-rope, which runs on pulleys over the principal and most dangerous parts of the stage. This rope is prepared so as to be the most combustible substance on the stage. In case of fire, it will, therefore, ignite and burn off almost instantly. Has this moment arrived, a heavy weight, held by the safety-rope, falls. This weight being connected with the machinery of the curtain by a lever, the lever is raised, the machinery set in motion, and the curtain lowered. Not, however, with a sudden fall which might damage it, but steadily.

The falling of the heavy weight, at the same time, opens the valve of the large smoke flue contained in the roof of the stage, whereby the smoke and heat of the fire is kept on the stage and taken out of the flue; thus giving the audience time to leave the theatre quietly and orderly, without being threatened by smoke or heat. The same moment the above takes place the fall of the weight sets a fire alarm in motion and the fire department is notified.

We have now seen the different devices for getting rid of that greatest danger to audiences—smoke—and can now compare their relative values. The first would be very simple, but in the time required for the firemen to arrive and break in the glass of the sky-light, the audience might be suffocated.

The second is an excellent patent, its only objection being, as before stated, its want of automatism.

The third, to the author, seems undoubtedly the best, for if in case of fire, the men having it in charge should neglect to open the valve, it would act automatically; not to speak of the immense value of the automatic wire drop-curtain and fire-alarm.

The writer has frequently noticed the time required by audiences to vacate theatres, and out of numerous experiments finds it takes from 3½ to 11 minutes for a theatre to be entirely emptied. But this time is protracted indefinitely in case of a panic. It has been found that in cases where audiences had ample time to vacate theatres many were killed, although not prevented from escaping by the smoke.

This is explained by the jamming of crowds in corridors. A mass of people may best be compared with a number of logs floating down a stream, which at some point, by their mutual pressure, form arches across it, thus becoming wedged fast. In the same manner persons form arches across corridors which are sometimes broken, only to be formed again.

This, the cause of many deaths, may be remedied by making the walls of corridors inclined towards each other, being narrowest in the theatre and widening towards the exit doors, as it is impossible for logs to jam in a widening water-course.

There should be outlets from each gallery or floor separate and distinct from every other outlet, so that a crowd from one gallery cannot precipitate itself upon a crowd from another floor that is struggling to get out.

A matter still sometimes neglected is, that all doors should open outwards, the people of the fourth gallery at the recent Vienna fire, for example, were hindered from flight by the doors opening inwards.

Most theatres have a sufficient number of exits, but in order to save doorkeepers most of them are locked; some not being satisfied with locking them, even nail and bolt them shut.

Corridors are also frequently too narrow; these should never be less than eight feet broad, which would allow, at most, but five persons abreast.

Another outrage to humanity are high galleries. In American theatres there are never more than three, but in Europe they have as many as five.

Law should forbid the erection of more than two galleries, *i. e.*, a "balcony" and "family circle."

The horrors of theatre fires are always increased by the total darkness which envelopes audiences a short time after commencement of the fire.

This is frequently caused by the explosion of gas on the stage. To obviate this, all theatres should separate the system of lighting the auditorium from that of lighting the stage.

After years of hard work, the authorities of Vienna succeeded in compelling managers to have oil lamps in corridors. The order was complied with, but, as was seen by the late catastrophe, these were never lighted.

It has frequently been urged, especially by "insurance men," that the risk from fire would only be increased by the use of coal oil in these lamps. But it is not necessarily said that petroleum must be used, for any of the heavy oils (used long before coal oil was known) might be employed with advantage.

If these should be objected to, let it be remembered that festivals which outrival everything in history by their splendor, and that the plays of a Corneille and a Moliere were first produced before the eyes of the then most powerful king of Europe, by the light of *candles*. Why should these then not satisfy us in the humble position of safety corridor lights?

Particular attention should be paid to the calamity at Carlsruhe in 1847. By the inattention of one of the servants in lighting the gas the drapings of the Grand Ducal box caught fire. All parts of the house were crowded, over 2000 persons being present. The flames instantly spread to the balcony; every one tried to escape in the greatest hurry. The audience of the parquet, as well as that of the balcony, saved themselves, but the greatest confusion ensued in the higher galleries which were in a short time filled with smoke.

Of the four exits, but the one under which the fire broke out was open. Every one rushed to this exit and very soon it was jammed shut. The scenes following were indescribable: A few climbed or jumped from the galleries; others threw themselves out of the windows; many were crushed to death, and most were suffocated by the hot smoke.

In the narrow corridors people were lying in heaps. To this was added that immediately after the breaking out of the fire the gas was turned off from the street and the building thrown into total darkness. The situation of the people, jammed fast in corridors, without light, enveloped in smoke, was frightful.

This catastrophe cost the lives of sixty-three persons, and over two hundred were terribly wounded.

As before mentioned, the theatre had four exits, but to save the expense of extra doorkeepers three of these had been closed for years, and not only locked, but nailed and boarded shut, and but few knew the existence of these extra exits.

One cause saved the lives of many—gas had not long ago been introduced and on this account many oil lamps had been retained to do duty in corridors. These lamps, which had been the objects of wit and sarcasm, saved the lives of hundreds.

We had at Vienna the counterpart of Carlsruhe, only in this case the lamps were not lighted or hundreds of unfortunate victims would have been saved.

It can, from this, be seen how necessary oil lamps are and that in the deciding moment this precaution will save many lives.

Before concluding my remarks it may be well for me to give an example of a theatre, which was managed in the correct manner, which had many of the modern improvements, and which at the same time is the first case on record in which *the entire* audience of a burning theatre escaped in safety. On the 16th of April, of this year, during a performance of the farce "Robert and Bertram," at the "Hof-Theater" of Schwerin, the cry of fire was suddenly heard from one of the galleries. As no flames or smoke were perceived the audience remained seated, until the news came from the outside that the roof was burning. The Grand Duke, who was present immediately addressed a few words to the audience and ordered the musicians to continue. The stage-manager also assured the audience that there was no danger. But soon the wire curtain had to be lowered, and now the audience left the theatre in the greatest order, especially the densely packed galleries were rapidly cleared, the audience escaping through the numerous exits, *which were all open.* For some time previous to the occurence audiences had been instructed—by means of large placards hung up in the corridors—how to act in case of fire. The *oil-lamps were all lighted,* and the wire-curtain was in *good working order,* thus for the first time, practically illustrating its use. On account of these excellent arrangements it was possible for the whole audience to save itself, although many ladies and children were present. Here we then have an example to show how, with proper precautions, faithful employés—especially the man who let down the wire-curtain—and cool, collected conduct, an audience may be spared the dangers of a theatre-fire. The beautiful theatre burned down, also the large Concert Hall attached to it. But the only life lost in the event was that of a fireman who was buried under a falling wall, this occurring a considerable time after the audience had escaped.

The author hopes to have shown how theatres can be built, although not fire-proof, yet in a manner so as to give safety to audiences.

Theatres *could* and *should* be built so that the largest audiences could escape in safety.

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